(12)UK Patent Application (19)GB (11) 2 119 218 A

(21) Application No 8311871
(22) Date of filing
29 Apr 1983
(30) Priority data
(31) 373762
(32) 30 Apr 1982
(33) United States of America (US)
(43) Application published
16 Nov 1983
(51) INT CL³ A23C 11/10 C07G 7/00
(52) Domestic classification
A2B 330 333 700 702 720 722 729 730 765 795 CB
A2Q 16B2 7B
C3H FX
U1S 1104 1338 A2B A2Q C3H
(56) Documents cited
GB 1585456
GB 1570746
GB 1564342
GB 1549206
GB 1507413
GB 0551692
US 3809771
(58) Field of search
A2B
A2Q
C3H
(71) Applicant
The Coca-Cola Company (USA–Delaware)
310 North Avenue
Atlanta
Georgia
United States of America
(72) Inventors
George L K Hunter
Daniel Bassell Dennison
Troy Griffeth Brawley
(74) Agent and/or Address for Service
Frank B Dehn and Co
Imperial House
15–19 Kingsway
London WC2B 6UZ

(54) Process for the preparation of soymilk

(57) A low cost soymilk that provides excellent nutritional quality, flavor and stability can be produced from the whole soybean on a commercial scale using a process which comprises the steps of

(a) forming from ground or milled dehulled soybeans an aqueous soybean slurry;

(b) adjusting the alkalinity of said soybean slurry to a pH of 8.5 to 9.5 by adding an alkaline agent thereto;

(c) cooking said soybean slurry for such a time that the pH of said slurry drops to a pH in the range of 7.5 to 8.2;

(d) neutralizing the soybean slurry to a pH of 7.0 to 7.4 with a strong mineral acid and then, if desired, adding further ingredients thereto to formulate a soymilk beverage; and

(e) homogenizing said soybean slurry to a homogenized soymilk.

The process does not require the conventional curd precipitation and centrifugation steps necessary for the removal of nonprotein components, sugars and fibrous materials.

GB 2 119 218 A

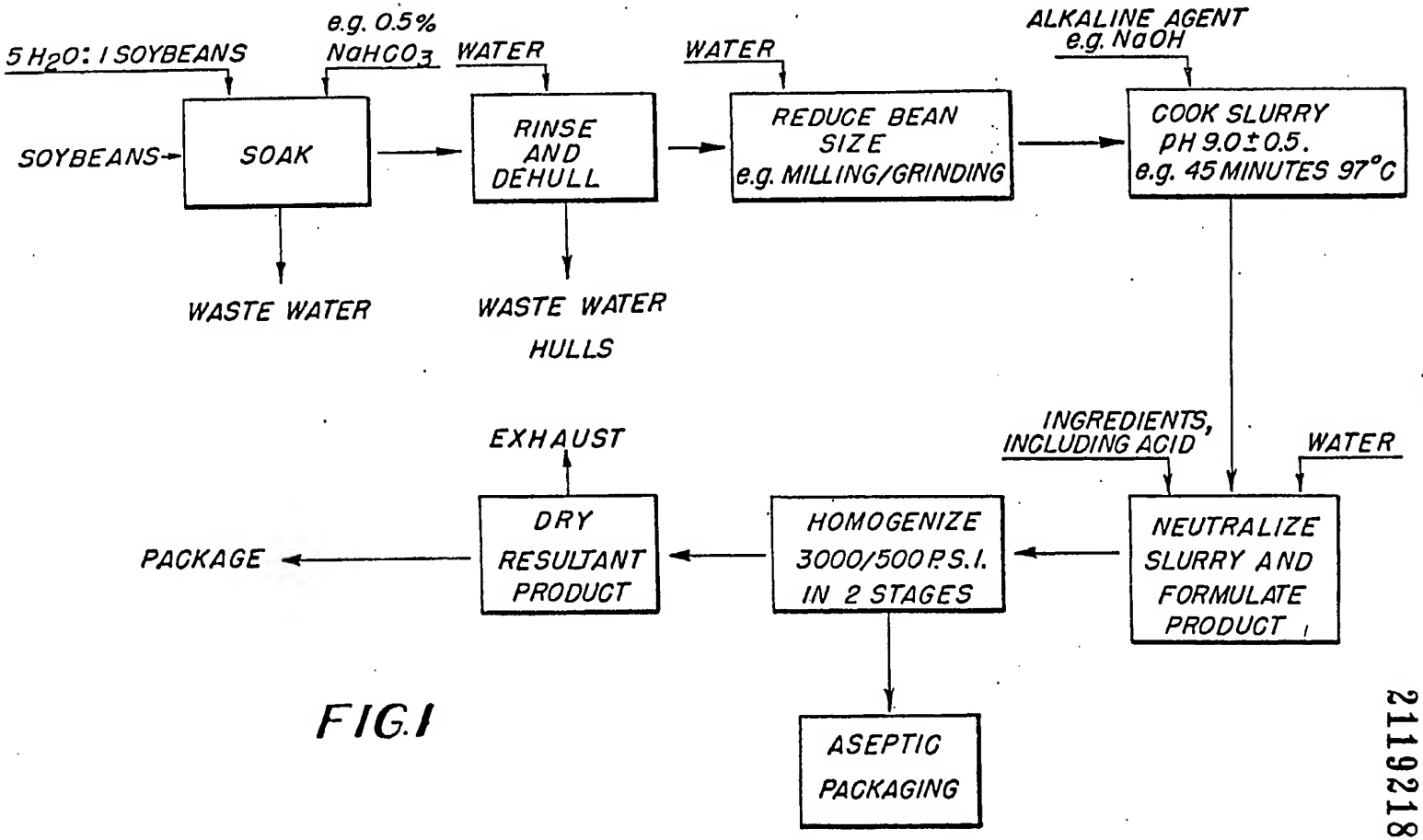

FIG. 1

1/2

2119218

2119218

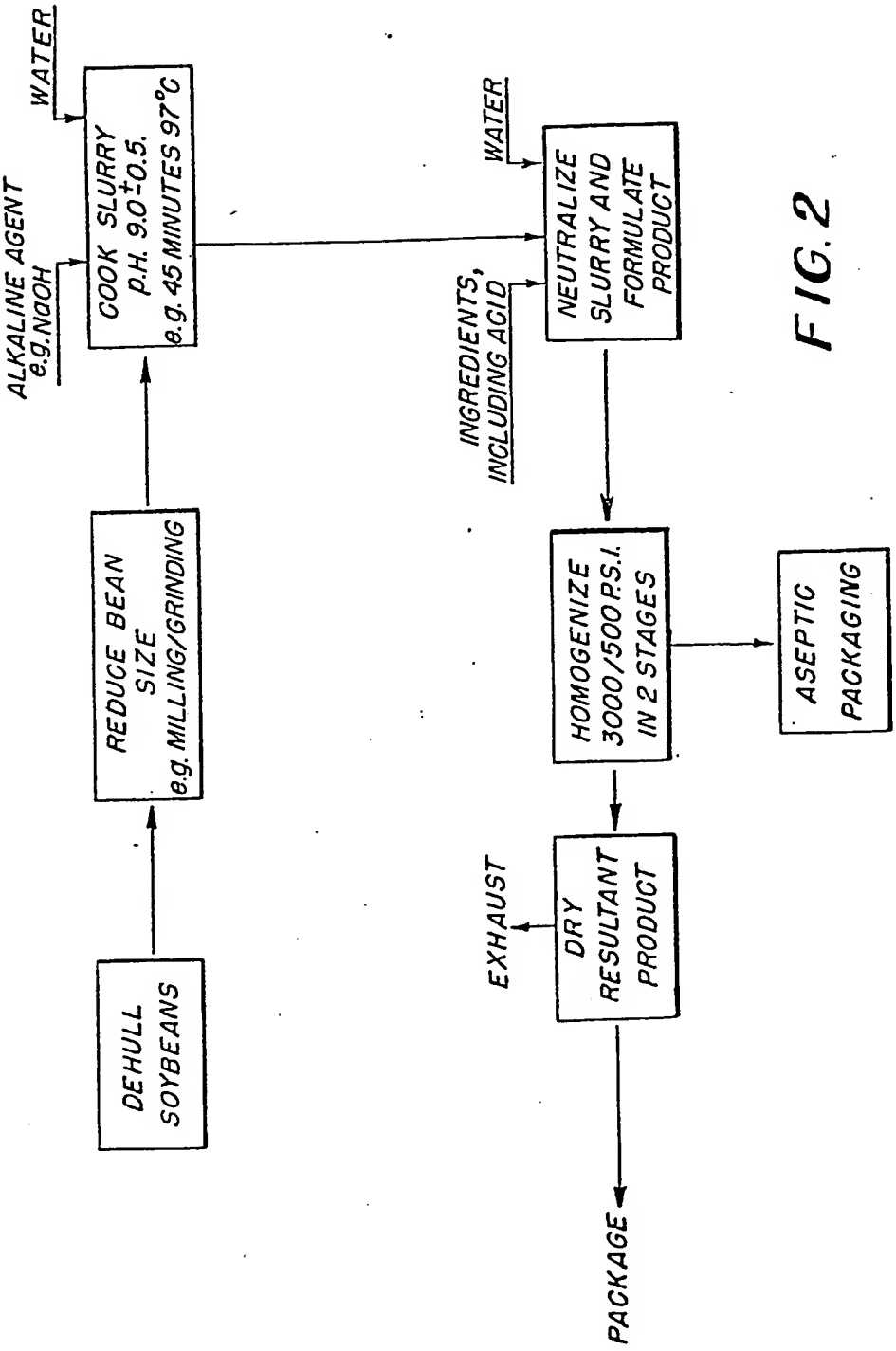

FIG. 2

SPECIFICATION

Process for the preparation of soymilk

This invention relates to a process for preparing a soybean beverage that eliminates the requirement for fiber removal.

Soybeans have long been recognized as an excellent source of macronutrients, particularly protein. The soybean is potentially a viable vegetable source for providing a large percentage of the world's protein demand. The dramatic increase in the world population has emphasized the necessity for a high quality protein supply in large quantities.

The wide scale use of soybeans in beverage applications has been hindered because of two basic problems:

1. An undesirable odor and flavor described as beany or painty that develops due to enzymes which catalyze the oxidation of polyunsaturated fats. The off-flavor develops rapidly when the cell structure is disrupted, permitting the enzyme and fat to come into contact.

2. A sensation characterized as throat-catching or scratchiness when swallowing which is reported to result from the presence of fiber or the action of *b*-glycodidase to form polyphenols.

The conventional process for preparing soymilk soaks the beans in water for several hours followed by grinding the beans in water to extract the protein. The resulting slurry is then filtered, and the aqueous protein containing filtrate is recovered and may or may not be heat treated. Although this process is simple, the finished beverage is not organoleptically acceptable, and a substantial percentage of the protein is lost in the filtration.

The prior art contains several approaches to removal of the fiber and improvement of the flavor and protein yield. The beany flavor is generally minimized by grinding the soybeans in hot water so as to inactivate the lipoxygenase enzymes. The fiber is generally eliminated by acid precipitation of the protein and centrifugation of the curd to effect fiber removal. The protein curd is then resuspended by neutralization for the soymilk formulation.

U.S. Patent No. 2,078,962 to Miller discloses a process in which soybeans are soaked and ground with water to form a slurry. The slurry is thereafter boiled, desired food ingredients are added and the slurry is then homogenized.

U.S. Patent No. 3,288,614 to Miles relates to a process for the preparation of soymilk which comprises dehulling soybeans, forming a slurry of the dehulled soybeans with water, pressure cooking the slurry at 104.44°C to 121.11°C for a period of time in the range of a mere flash to a maximum of ten minutes, and thereafter adding various food ingredients to the slurry to obtain the desired final composition, homogenizing the slurry and then spray-drying said slurry. Specifically, see Example I in Column 2, line 28 bridging Column 3 to line 39.

U.S. Patent No. 3,639,129 to Mustakas, *et al.* discloses a process in which a full-fat soybean flour is dispersed in water to make a slurry; the slurry is milled to reduce particle size of the flour particles in the slurry; the milled slurry is homogenized and thereafter spray-dried.

U.S. Patent No. 3,809,771 to Mustakas, *et al.* relates to the preparation of a full-fat oilseed beverage by suspending full-fat oilseed flour and water and activating the lipoxygenase, precipating the lipid-protein, resuspending the precipitate and water at pH of about 9, heating and cooling the suspension, adjusting the pH to about 7 and clarifying. U.S. Patent No. 4,194,018 to Hodel, *et al.* discloses a process for producing an aqueous soya suspension by grinding soya beans in the presence of water at a temperature of from 90° to 100°C to form a dispersion of particles of which the majority have dimensions of the order of 100 to 500μ; heating the dispersion by the injection of steam to a temperature of from 120° to 160°C thereby destroying the antitrypsin factor; and grinding the dispersion to form a suspension containing corpuscles of protein and fat with dimensions on the order of 2 to 10μ and cell wall debris of which the largest dimension does not exceed substantially 40 to 300μ.

Hand, *et al*, in Food Technology, Vol. 18, December 1964, pages 139–142 disclose a process for preparing soymilk comprising the steps of soaking and dehulling soybeans, passing said beans through a disintegrator in the presence of water in an amount sufficient to make a slurry containing 16% solids, homogenizing the slurry and thereafter spray-drying.

Johnson, *et al.* in Journal of Food Science, Vol 48, pages 239–243, 1981 disclose a process for processing soymilk by steam-infusion cooking wherein traditional soymilk is boiled for approximately 60 minutes at 99°C pH 6.7, which reduces trypsin inhibitor (TI) activity by more than 90% to improve nutritional value. Evaluation was continuous and direct steam-infusion cooking facilitated higher temperatures (99°C to 154°C) than that traditionally used for cooking soymilk. At temperatures about 120°C in steam-infusion cooking it was observed that consistent temperature-dependent patterns in yields of soymilk, solids and protein was characterized by an initial decrease followed by a rise to maximum recovery, then by a final decrease. At 154°C, pH 6.7, maximum recovery occurred at the same point as did adequate inactivation of TI. As much as 90% of the slurry, 86% of the soybean solids and 90% of the protein was recovered as soymilk after centrifuging at

1050 × G for 5 minutes Under optimum conditions for steam-infusion cooking, the soymilk also retained less than 8% residual TI activity and less chemical browning. Using traditional cooking methods, about 72% of the slurry, 61% of soybean solids and 73% of the protein are recovered.

It is an object of the present invention to provide a simplified process for the manufacture of a soymilk beverage that does not adversely affect the protein quality. Accordingly, it is the primary aim of the invention to provide for greater than 95% utilization of the protein in the raw soybean.

Further, another object of the invention is to provide a process for preparing a soymilk beverage which is versatile in that the starting material may be raw soybeans, full-fat flour or defatted flour.

Also, an object of the invention is to provide a finished organoleptically acceptable soymilk product in liquid form or one which may be easily reconstituted from powder.

Further, an object of the invention is to provide a low cost soymilk, which gives a taste and mouthfeel comparable or superior to existing products in the market made from soy isolate or other processes, said soymilk being producible from whole soybean on a commercial scale.

Finally, it is an object of this invention to provide a process for producing soymilk which uses a simplified process technology and requires lower capital investment.

According to the present invention we therefore provide a process for the preparation of soymilk which process comprises the steps of:

a) forming from ground or milled dehulled soybeans an aqueous soybean slurry, advantageously a slurry containing 5 to 15 percent by weight total solids;

b) adjusting the alkalinity of said soybean slurry to a pH of 8.5 to 9.5 by adding an alkaline agent thereto;

c) cooking said soybean slurry, suitably at a temperature of from 95°C to 98°C, for such a time, e.g. 30 to 45 minutes, that the pH of said slurry drops to a pH in the range of 7.5 to 8.2;

d) neutralizing the soybean slurry to pH of 7.0 to 7.4 with a strong mineral acid and then, if desired, adding further ingredients thereto to formulate a soymilk beverage; and

e) homogenizing said soybean slurry to a homogenized soymilk.

The homogenizing step (e) is conveniently effected in two stages, the homogenizing pressure in the first stage suitably being 17.24 to 24.13 MPa gauge (2,500 to 3,500 p.s.i.g.) and the homogenizing pressure in the second stage suitably being about 3.45 MPa gauge (500 p.s.i.g.).

The process of the invention preferably further comprises the precursor steps of

(i) soaking the soybeans in from 3 to 5, suitably 5, times their weight of water;

(ii) rinsing and, if required, dehulling said soybeans; and

(iii) reducing the bean size of the dehulled soybeans by grinding or milling said soybeans.

The process of the invention may further comprise the steps of aseptically packaging the homogenized soymilk or spray drying the homogenized soymilk to provide a soybean beverage powder.

The process of the present invention thus may utilize dehulled, split soybean which undergoes soaking, rinsing, grinding (wet milling), cooking and formulation processes. The neutralized and if desired formulated product may then be sterilized, homogenized and finally aseptically packaged. Soymilk produced by this process has a bland flavor and smooth mouthfeel. The taste and sensual characteristics are equal or superior to that of soymilk produced by other existing methods and the process enables a protein recovery (excluding hulls) from the soybean starting material of more than 95% to be achieved.

Pursuant to the invention, the soybean slurry is preferably neutralized with a strong mineral acid selected from the group consisting of HCl, H_2SO_4 and H_3PO_4; especially preferred is HCl.

Also, in accordance with the invention, the alkalinity of said soybean slurry preferably is adjusted to a pH of 8.5 to 9.5, preferably about 9.0, with an alkaline agent selected from the group consisting of NaOH, KOH and $Ca(OH)_2$. An about 50% solution of NaOH is an example of a convenient alkaline agent.

In carrying out the preferred procedure of the invention, the soybeans are soaked in about 5 times their own weight of water and optionally in the presence of an alkaline agent, such as $NaHCO_3$.

In a particularly preferred embodiment the invention provides for the manufacture of a bland tasting soymilk beverage essentially free of throat-catching sensation by: (1) hydrating whole soybeans or dehulled soybeans; (2) grinding the hydrated soybeans in hot water; (3) diluting and cooking the soybean slury at an alkaline pH; and (4) formulating, homogenizing and aseptically packaging the resultant soymilk product.

Preferred embodiments of the invention will now be described by way of example and with reference to the accompanying drawings in which:–

Figure 1 is a schematic representation of a preferred procedure of the invention.

Figure 2 is a schematic representation of a further preferred procedure of the invention.

While the invention will be described in connection with a preferred procedure, it will be understood that it is not intended to limit the invention to that procedure.

Soybeans of all varieties may be employed, such as Corosoy, Clark, Bragg, Amsoy, etc., in practising this invention. Preferably the soybeans are air-cleaned and free of defective beans and foreign matter.

Turning first to Fig. 1, there is shown a schematic drawing of a preferred process of the invention. The object of the soaking step is to fully hydrate the soybeans so as to make the subsequent grinding step more efficient and to leach out some of the oligosaccharides and sugars associated with the production of flatulence in humans. The bean hydration requires a bean to water ratio of 3 to 5:1. Typical composition of the soak solution which is to be discarded is: 0.75% protein, 3.9% carbohydrate (2.6% soluble sugars: sucrose, raffinase, stachyose) and 1.4% ash. The rapid method is preferred for hydration of the beans because of speed and inactivation of the lipoxygenase enzymes associated with off flavor. The soaking step may optionally be conducted in the presence of an alkaline agent, such as sodium bicarbonate.

The hydrated soybeans then should be rinsed with water prior to grinding. Although it is preferred to begin with clean dehulled soybeans, whole soybeans may be utilized in the soak step with an appropriate wet dehulling process.

The hydrated soybeans are then passed together with water through an Alpin Kolloplex Mill to yield a slurry of 5 to 15% total solids. It is preferred that the water temperature be about 90°C. If it is desired to make a soymilk which contains the green-beany flavor, then the water temperature for hydration of the beans and for milling should be at ambient so as not to inactivated the lipoxygenase enzymes. The resulting slurry is then allowed to stand until the desired flavor is developed. The remainder of the process applies to both the bland and beany soymilks.

The soybean slurry is then adjusted to pH 9.0 ± 0.5 with an alkaline base such as NaOH, KOH or $Ca(OH)_2$ and then cooked at 95°C to 98°C for 30 to 45 minutes. Shown is a cook temperature of 97°C for 45 minutes. The combination of alkaline pH and high temperature renders the fiber in a state such that after homogenization, the soybean slurry possesses none of the throat-catching sensation or chalkiness. It is important to maintain the cook temperature of the slurry below a rolling boil so as to minimize foaming. Further, this step is sufficient to inactivate the trypsin inhibitor. During the cook step, the pH drops from an initial 9.0 to 7.5 to 8.2 at the end. It may be hypothesized that the drop in pH is due to the unfolding of certain protein globulins and/or the release of bound salts which now act as buffering aids. The alkaline base used in the cook step can influence the final viscosity of the soymilk, given that the other processing steps and the formulation are identical.

Upon completion of the alkaline cook step, the bean slurry is neutralized to pH 7.0 to 7.4 with any strong mineral acid, such as HCl, H_2SO_4 or H_3PO_4. The soybean slurry may then be formulated into a finished soymilk beverage by adding sugar, salt, emulsifier, color and flavoring, if desired. The soybean slurry is then homogenized, preferably in a two-stage unit at 20.68 to 27.58 combined MPa gauge (3,000 to 4,000 combined p.s.i.g.). The homogenized liquid soymilk may then be packaged as desired or it may be spray-dried to provide a soymilk beverage powder.

One concern with the alkaline cook process is with the possible loss of sulfur amino acids and the formation of lysinoalanine, thus substantiallylowering the protein quality. Soymilk samples were prepared according to the process outlined, freeze-dried after the alkaline cook step, and the protein quality evaluated. The corrected P.E.R. (protein efficiency standard) was 1.78, which indicated that the protein quality is comparable to that of soy isolate and that no adverse reactions with the amino acids occurred. As so far described, the procedure schematised in Fig. 1 is substantially similar to that of Fig. 2. The two differ primarily in that the soak and rinse steps are eliminated in Fig. 2.

The process of the invention will now be further illustrated by the following non-limiting Examples. In these Examples percentages are by weight unless otherwise indicated.

Example 1

Dehulled Corosoy soybean splits (34.25 kg) were added to 137 kg 90 to 95°C water in a jacketed kettle containing 0.25% $NaHCO_3$. The beans were permitted to hydrate in the water for 75 minutes, taking up approximately 1.2 times their weight in water. The hydrated beans were then rinsed with tap water to remove any residual surface dirt which was discarded with the soak solution. The soybeans were then immediately passed through an Alpin Kolloplex Pin Mill (Alpin American Co.; Natick, Mass.) with hot water. The ground soybean slurry was diluted to the desired 2% protein content (which corresponds to about 5% by weight total solids in the slurry) in a jacketed kettle, and the pH was adjusted to 9.0 with NaOH. The temperature was raised to 97°C and the slurry cooked for 45 minutes with good agitation. At the end of the cook, the pH had dropped to approximately 7.8, and then was further adjusted to 7.2 with HCl. Sugar (41.4 kg), salt (0.823 kg) and emulsifier were then added and water replaced as so to provide a 2% protein soymilk beverage. The beverage was passed through a two stage Manton-Gaulin homogenizer using 20.68 and 3.45 MPa (3000 psi and 500 psi) for stages 1 and 2, respectively. The homogenized soymilk was

sterilized by UHT using a Spiratherm indirect tubular heat exchanger at 140°C for five seconds and packaged aseptically in 250 ml Tetrabrik(R) packages.

This soymilk was free of the beany or green flavor and odor generally associated with soymilks. The throat-catching sensation and chalkiness usually associated with the fiber was also absent. Storage in Tetrabrik(R) at ambient and refrigeration temperatures showed excellent colloidal stability with only a trace sediment observable after three months. The beverage was evaluated organoleptically and found to possess good flavour and mouth-feel.

Example 2

The invention may be better understood following a description of a commercial operation.

Soaking and Rinsing

A desired amount of dehulled split soybean is weighed and fork-lifted onto a soak tank platform. Two soak tanks may be employed in a staggered schedule. Soybeans are charged to one of the soak tanks and rinsed twice with potable water. It is desired that the soak tanks be equipped with a removable perforated plate at the bottom to facilitate rinse water drain. After rinsing, hot water is charged to the tank, and the beans soak for 75 minutes or until they are fully hydrated. During the soaking period, live steam is injected into the tank to maintain the temperature at approximately 90°C with an automatic temperature control valve. The steam injection also provides mild agitation to the bath of the bean. The soaking process softens the bean fiber, removes bitter tasting components from the bean and effectively inhibits enzyme catalyzed rancidity, yielding a good tasting product. This moist heat treatment also destroys the trypsin inhibitors and the hemaglutinin which are the biologically active components of the soybeans.

When fully hydrated the volume of the bean increases about 2.7 times of its original volume and has a bulk density of 623 grams per liter. After the beans are fully hydrated, the soak water is drained, and once again, the beans are rinsed twice with potable water. The fully hydrated soybeans are fed to a Alpine mill equipped with a Star-flow volumetric feeder installed at the outlet of the soak tank. The Star-flow volumetric feeder utilizes a variable speed feeder blade in conjunction with a stationary flow cone. The blade sweeps material from the perimeter in and under the cone towards the center where it is discharged. Other volumetric feeder such as the vibrating bin, the screw feeder or a diaphragm slurry pump may be considered.

Grinding or Wet Milling

The Alpine mill is an impact study mill with one rotating and one stationary stud disc. The Alpine Killoplex Model 250Z and Model 400Z may be employed in a single line operation and a double line operation, respectively. The grinding may take approximately 1 hour per batch, both for a single line operation and a double line operation.

During the grinding process, approximately 4 to 8 liters per minute of water is fed into the soak tank through the spray ball to lubricate the bean passage and continuously wash out the ground bean paste inside the mill. The ground soybean slurry is then pumped into a cooker equipped with a positive displacement pump for further processing.

Cooking

The cooking is carried out in a steam jacketed cooker. An amount of water is added to the bean slurry to obtain a soymilk with 5% total solids. The alkalinity is adjusted to pH 9 with 50% w/w caustic solution. Steam is injected into the heating jacket, and the temperature is maintained between 95°C and 98°C with an automatic temperature control valve. Higher cooking temperature will cause excessive foaming. Constant agitation is required to facilitate heat transfer and keep the particles in suspension. The cooking process further reduces the fiber size after grinding. The cooking process takes approximately 45 minutes per batch.

Neutralization and Formulation

After cooking, the soymilk is neutralized with a small amount of hydrochloric acid. An electronic pH meter with temperature compensation may be used for this purpose. A desired amount of sugar, salt and emulsifier is added to complete the formulation of the soymilk. Soymilk will then be transferred to a Cherry Burrell Unitherm UHT processing unit which is controlled by the level probe in the surge tank of the UHT unit.

UHT (Ultra High Temperature) Processing and Homogenizing

The soymilk is heated up to 140°C in two stages with tubular heat exchangers and held at 140°C inside the holding tube for four seconds. The product is then cooled to 65.5°C with cooling tower water and passed through the double stage homogenizing valve, with combined homogenizing pressures of 20.68 to 27.58 MPa gauge (3,000 p.s.i.g. to 4,000 p.s.i.g). The product subject to this heat shock will be totally sterilized and will preserve the original taste and flavor. The product will then be further cooled down to room temperature (26.7°C) and conveyed in a closed system to the packaging machine. The operation of the UHT unit is totally synchronized with the Tetrabrik(R) packaging machine.

CLAIMS

1. A process for the preparation of soymilk which process comprises the steps of:

(a) forming from ground or milled dehulled soybeans an aqueous soybean slurry;

(b) adjusting the alkalinity of said soybean slurry to a pH of 8.5 to 9.5 by adding an alkaline agent thereto;

(c) cooking said soybean slurry for such a time that the pH of said slurry drops to a pH in the range of 7.5 to 8.2;

(d) neutralizing the soybean slurry to a pH of 7.0 to 7.4 with a strong mineral acid and then, if desired, adding further ingredients thereto to formulate a soymilk beverage; and

(e) homogenizing said soybean slurry to a homogenized soymilk.

2. A process as claimed in claim 1 further comprising the step of:

(f) aseptically packaging said homogenized soymilk.

3. A process as claimed in claim 1 further comprising the step of:

(f) spray-drying said homogenized soymilk to provide a soymilk beverage powder.

4. A process as claimed in any one of claims 1 to 3 wherein said strong mineral acid utilized in step (d) is selected from HCl, H_2SO_4 and H_3PO_4.

5. A process as claimed in claim 4 wherein said strong mineral acid utilized in step (d) comprises HCl.

6. A process as claimed in any one of claims 1 to 5 wherein in step (b) the pH of the soybean slurry is adjusted to about 9.0 with an alkaline agent selected from NaOH, KOH and $Ca(OH)_2$.

7. A process as claimed in claim 6 wherein in step (b) the pH of the soybean slurry is adjusted to about 9.0 with an about 50% solution of NaOH.

8. A process as claimed in any one of claims 1 to 7 wherein in step (c) the slurry is cooked at a temperature of from 95 to 98°C.

9. A process as claimed in claim 8 wherein in step (c) the soybean slurry is cooked at a temperature of from 95 to 98°C for 30 to 45 minutes.

10. A process as claimed in any one of claims 1 to 9 wherein in step (c) the cook temperature of the slurry is maintained below a rolling boil so as to minimize foaming.

11. A process as claimed in any one of claims 1 to 10 wherein in step (a) there is formed a slurry containing 5 to 15% by weight total solids.

12. A process as claimed in any one of claims 1 to 11 wherein homogenizing in step (e) is effected in two stages.

13. A process as claimed in claim 12 wherein the homogenizing pressure in the first stage is 17.24 to 24.13 MPa gauge (2500 to 3500 psig).

14. A process as claimed in either of claims 12 and 13 wherein the homogenizing pressure in the second stage is about 3.45 MPa gauge (500 psig).

15. A process as claimed in any one of claims 1 to 14 wherein prior to process step (a) the following further process steps are effected:

(i) soaking soybeans in from 3 to 5 times their weight of water;

(ii) rinsing and, if required, dehulling said soybeans; and

(iii) reducing the bean size of the dehulled soybeans by grinding or milling said soybeans.

16. A process as claimed in claim 15 wherein in step (i) the soybeans are soaked in about 5 times their own weight of water.

17. A process as claimed in either of claims 15 and 16 wherein in step (i) the soybeans are soaked in water at about 90°C for 60 to 90 minutes.

18. A process as claimed in any one of claims 15 to 17 wherein in step (i) the soybeans are soaked in the presence of an alkaline agent.

19. A process as claimed in claim 18, wherein the said alkaline agent is sodium bicarbonate.

20. A process as claimed in any one of claims 15 to 19 wherein in step (i) the soybeans are soaked in the presence of steam and the temperature is maintained at a temperature of about 90°C.

21. A process as claimed in any one of the preceding claims wherein in step (c) steam is injected and the temperature is maintained at 95°C to 98°C.

22. A process as claimed in any one of the preceding claims wherein in step (a) the aqueous soybean slurry is formed at a temperature of about 90°C.

Printed for Her Majesty's Stationery Office
by Burgess & Son (Abingdon) Ltd.—1983.
Published at The Patent Office, 25 Southampton Buildings,
London, WC2A 1AY, from which copies may be obtained.